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A Critical Review of Attentional Threat Bias and Its Role in the Treatment of Pediatric Anxiety Disorders

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Threat bias, or exaggerated selective attention to threat, is considered a key neurocognitive factor in the etiology and maintenance of pediatric anxiety disorders. However, upon closer examination of the literature, there is greater heterogeneity in threat-related attentional biases than typically acknowledged. This is likely impacting progress that can be made in terms of interventions focused on modifying this bias and reducing anxiety, namely attention bias modification training. We suggest that the field may need to "take a step back" from developing interventions and focus research efforts on improving the methodology of studying attention bias itself, particularly in a developmental context. We summarize a neurocognitive model that addresses the issue of heterogeneity by broadly incorporating biases toward and away from threat, linking this variation to key neurodevelopmental factors, and providing a basis for future research aimed at improving the utility of threat bias measures and interventions in clinical practice.

Keywords: attentional threat bias; anxiety; children; avoidance; neurocognitive model; attention bias modification training

Attentional threat bias (TB), defined as exaggerated attention toward threatening information and stimuli, is hypothesized to play a central role in the etiology and maintenance of anxiety disorders (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Mathews & Mackintosh, 1998; Mathews & MacLeod, 1985; Puliafico & Kendall, 2006). Potentially, focusing attentional resources toward threatening stimuli, rather than benign stimuli or signals of safety, contributes to the development of anxious behavior and ultimately clinical impairment (Lonigan, Vasey, Phillips, & Hazen, 2004). Furthermore, it may confirm anxious expectations that threat is present, thus sustaining anxiety. A direct extension of this conceptualization has been the development of interventions to decrease anxiety by training attention

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away from threat, referred to as *attention bias modification training* (ABMT). Despite initial enthusiasm for such treatments and attention bias theories on which they are based, it has become increasingly apparent that significant variability in TB exists, particularly in pediatric studies. Although there is support for attention biases toward threat, there is also evidence of attention biases away from threat (Brown et al., 2013; Monk et al., 2006; Salum et al., 2013) as well as studies that do not find any discernible attention bias (Britton et al., 2012; Britton et al., 2013; Price et al., 2013). The source of such heterogeneity remains largely unknown, thereby limiting our understanding of the etiology of pediatric anxiety disorders and the applicability of targeted treatments such as ABMT.

This review examines TB in pediatric anxiety with a specific focus on its variability. We focus our discussion on one particular method of assessment, the dot probe task, to remove inconsistencies caused by different paradigms. The dot probe was chosen because it is the most widely used task in behavioral and neuroimaging studies and the basis for most types of ABMT (see Bar-Haim et al., 2007 for a complete review of measures). After a brief review of the pediatric TB literature, we will consider diagnostic characteristics as well as methodological issues that may contribute to heterogeneous findings. We will then discuss a neurocognitive model that broadly incorporates biases toward and away from threat as well as the presence of no stable bias, within a developmental framework. We conclude with a discussion of the clinical implications of these findings. Although our aim is to provide a review of the pediatric literature, we also draw from adult findings because of the paucity of research in this area, particularly in terms of neural mechanisms.

Heterogeneity of Attentional Biases

Behavioral evidence for the association between anxiety and increased attention toward threat has been garnered from a range of behavioral tasks; most common among them are variants of the dot probe task. The dot probe task was developed to measure this preferential allocation of attention by briefly presenting two stimuli simultaneously (e.g., an angry face and a neutral face) followed by a probe in the location of either stimulus (MacLeod, Mathews, & Tata, 1986). Participants are instructed to respond by indicating the location of the target as quickly and accurately as possible. The target is presented equally often in both locations; thus, faster reaction times to the probe when it is in the location of the threat stimulus suggests an attentional bias toward threat. When response times to the probe do not differ in relation to the stimulus presented, no consistent bias is detected, which is the typical response pattern in nonanxious individuals. Studies using the dot probe have demonstrated attentional biases using various stimuli (e.g., words, pictures, emotional faces) and stimulus durations (Bar-Haim et al., 2007; Puliafico & Kendall, 2006). The most common design used in the studies of pediatric anxiety discussed in the following text present emotional faces for a duration of 500 ms.

As mentioned earlier, there is significant evidence supporting TB in pediatric anxiety. In a meta-analysis of 11 studies, Bar-Haim et al. (2007) found reliable detection of TB in clinically anxious and high trait anxious youth ($d = 0.50$). Additional studies published since 2007 have found similar results (Roy et al., 2008; Shechner et al., 2013). Studies of inhibited temperament further support a role of TB in the etiology of pediatric anxiety disorders. For example, Perez-Edgar and colleagues have found that behavioral inhibition, a temperamental risk factor for anxiety, in toddlerhood (Perez-Edgar et al., 2011) and early childhood (Perez-Edgar et al., 2010) only predicts increased social withdrawal later in development in those children displaying TB measured via the dot probe task.

In addition to the substantial evidence supporting attentional bias toward threat, others have found a bias in the opposite direction, away from threat (Brown et al., 2013; Monk et al., 2006; Salum et al., 2013). That is, children with anxiety disorders responded more quickly to probes replacing nonthreatening stimuli, suggesting a pattern of attentional avoidance of threat. Clinical research has long emphasized the role of *behavioral* avoidance of fear-provoking situations in the development and maintenance of anxiety disorders. Such avoidance is at the root of most functional impairment in these children and adolescents. For example, those with social phobia avoid situations such as parties or play dates, which limit contacts with peers and interferes with typical social development. Relatedly, *attentional* avoidance, as evidenced by a bias away from threat, might play a greater role in the etiology or maintenance of anxious symptoms than has been considered. In a large-scale twin study examining behavioral and familial risk for anxiety, children diagnosed with an anxiety disorder evidenced greater attentional avoidance of threat-related stimuli than their nonanxious peers (Brown et al., 2013). The magnitude of avoidance predicted the incidence of anxiety disorders independently from risk associated with familial factors.

Finally, several investigators have failed to find evidence of any significant bias at all (Britton et al., 2012; Britton et al., 2013; Price et al., 2013). The lack of a consistent bias suggests a variable response pattern with attention distributed evenly across stimuli, potentially reflecting greater cognitive flexibility, which is characteristic of nonanxious youth. These children may represent a subgroup of anxious youth for whom attentional flexibility is relatively intact. Alternatively, an option that cannot be ruled out is that there is significant interindividual variability that is not captured by the use of an average group bias score (see the following text for further discussion of this as a limitation of the dot probe). Within each study, there may be some participants exhibiting TB and others showing biases away from threat resulting in an overall lack of bias at the group level. Further investigation of this group of anxious youth is needed to determine if they represent a unique phenotype or result from methodological confounds.

Sources of Heterogeneity

Diagnosis

Evidence suggests that anxiety characteristics may be a contributing factor to this observed heterogeneity in attentional biases in pediatric anxiety. For example, greater anxiety disorder severity has been shown to be associated with a bias toward threat (Waters, Mogg, Bradley, & Pine, 2008). Furthermore, more recent studies have found TB differences associated with type of anxiety disorder. Specifically, "distress" disorders such as generalized anxiety disorder (GAD) and posttraumatic stress disorder (PTSD) may be characterized by a bias toward threat, whereas "fear" disorders such as phobias may be associated with a bias away. This is supported by a large community-based study of more than 1,700 children (ages 6–12 years) that found that children with "distress disorders" including GAD and PTSD and high internalizing symptoms showed bias toward threat, whereas those with "fear disorders" and high internalizing symptoms exhibited a bias away (Salum et al., 2013). Of note, only a few children exhibited comorbidity with anxiety disorders from the other category, and these were excluded from the analyses. Waters, Bradley, and Mogg (2014) found similar results in a study of 233 clinic-referred children (ages 5–13 years) despite the presence of significant comorbidity across categories. Of the 158 children with a principal fear disorder (separation anxiety disorder, social phobia, or specific phobia), 57% had comorbid GAD, and of 75 with a principal distress disorder (GAD), 80% had a comorbid fear disorder. Earlier studies also support this distinction. For example, Monk et al. (2006) found significant attentional biases away from threat in their sample of GAD adolescents completing a functional magnetic resonance imaging (fMRI) scan during the dot probe. Overall, these studies not only provide a putative basis for heterogeneity in attention bias across and within studies of anxious youth but also suggest that attention away from, or avoidance of, threat may represent another significant bias in pediatric anxiety disorders, particularly those characterized by fear reactions.

Methodological Issues

Although there is significant evidence supporting true variation in TB across anxious youth, methodological issues may also explain differences in response patterns. For example, there are no standard criteria for defining exaggerated attention to threat as measured by the dot probe. That is, what is considered a bias toward threat in one study may differ from another. Some studies have used a specific reaction time advantage such as 8 ms (Eldar et al., 2012) and classify attentional TB at the individual level. Others have indicated a bias if the mean score of a group is significantly different from zero (O'Toole & Dennis, 2012; Perez-Edgar, Kujawa, Nelson, Cole, & Zapp, 2013; Roy et al., 2008). A limitation of the latter method is that average scores can obscure individual differences within a group. For example, in the Roy et al. (2008) anxious sample, even though the group demonstrates a mean bias toward threat, scores ranged from −89.1 to +133.4 ms. More specifically, using a cutoff of 8 ms in either direction, there are 34 children with a bias away from threat, 48 with a bias toward threat, and 19 with no bias. Furthermore, there is no "standard" dot probe paradigm; individual studies vary in terms of the stimuli used, their location on the screen and their duration, as well as the responses required. For example, simple probe detection studies ask participants to indicate the side of the screen on which the probe appears, whereas probe discrimination methods require the respondent to identify the probe itself. There is no clear evidence of the impact of these methodological differences on attentional biases, particularly in children. Meta-analytic methods have found no moderating effects of stimulus duration or type (pictures vs. words) on TB in adults, but child studies were too few to conduct similar analyses (Bar-Haim et al., 2007). Of note, most studies described here used highly similar methods (face stimuli presented at 500 ms) with variable results; thus, methodology is not likely the sole source of these bias differences.

In addition to limited standardization, the reliability of the dot probe has been called into question. In a study of nonreferred 9-year-old children (mean anxiety scores in the average range), the dot probe, along with other measures of TB, were administered 3 times at approximately 2-week intervals (Brown et al., 2014). Although mean reaction times showed substantial split-half and test–retest reliability, bias scores calculated as reaction time differences between threat and nonthreat cueing conditions yielded test–retest reliability coefficients near zero, suggesting low or nonexistent reliability. Similarly, Britton et al. (2013) showed a lack of stability in TB in a study of 12 nonreferred adolescents who completed the dot probe during two fMRI scans approximately 3 months apart. Of note, these studies were conducted with nonreferred children who are not expected to show a discernible bias, which likely affects reliability. No studies have assessed the test–retest reliability of TB in clinically anxious youth. Such investigations are critical because poor reliability of the dot probe may not only be affecting descriptive studies of TB but has significant implications for ABMT studies that rely on pre- and posttreatment assessments to demonstrate effects.

Recent efforts to address some of these limitations have involved the use of eye tracking, allowing closer examination of the timescale of attentional vigilance and avoidance in anxious youth. Tasks used are similar to the dot probe but rather than using reaction times as the dependent variable, which have limited reliability, they use a passive viewing approach to assess direction and duration of fixation as measures of attention toward threat. Findings in pediatric samples remain mixed. For example, some have found evidence of an initial orienting toward threat stimuli in anxious youth (In-Albon, Kossowsky, & Schneider, 2010; Shechner et al., 2013), whereas others have found no TB (Gamble & Rapee, 2009) or evidence of a bias away from threat (Gamble & Rapee, 2009; Price et al., 2013). In the study by Price et al. (2013), both anxious and nonanxious groups showed a bias away from threat assessed based on eye movements and no bias using traditional reaction time measures. Overall, despite improved methodologies, heterogeneity in attention bias in pediatric anxiety remains, suggesting that it is not likely a result of measurement alone but may represent important phenotypic variations that require empirical attention.

Neurocognitive Model

A review written by Cisler and Koster (2010) provides a neurocognitive model of attentional bias that addresses this variability in behavioral assessments of TB, by highlighting the importance of considering both automatic and strategic stages of information processing. Within this framework, anxiety is characterized by facilitated attention to threat during early stages of attention capture. This automatic response, often referred to as a *bottom-up* process, occurs outside of conscious control and is driven primarily by subcortical regions such as the amygdala. This is not well-examined by behavioral tasks such as the dot probe where reaction times are measured long after this initial orienting is complete and other processes have been initiated. Once threat is detected, strategic "top-down" processes that rely on cognitive control regions are recruited to manage the threat, typically by shifting attention and disengaging from the stimulus. At this processing stage, an observed bias toward threat reflects a reduced ability to successfully disengage. In contrast, individuals exhibiting a bias away from threat shift their attention away from the threat and avoid it, exhibiting a heightened attentional avoidance response. Thus, a preattentive bias toward threat or salient stimuli may be a uniform characteristic of anxiety, but the biases observed using behavioral probes reflecting the strategic processing stages that follow are more variable, particularly in children and adolescents. We now discuss this model in further detail regarding the neural mechanisms underlying attention to threat at each of these levels and how these may be disrupted in anxious youth.

Facilitated Attention

First, anxiety is characterized by an automatic facilitated attention to threat. Measurement of this initial attentional capture is not easily accomplished using behavioral techniques such as the dot probe because the temporal resolution is limited. However, it has been demonstrated in children and adolescents using eye-tracking methods. A recent study showed that anxious youth demonstrated a greater attention bias toward angry faces in the early phases of stimulus presentation (Shechner et al., 2013). Specifically, they were more likely to direct their first fixation at the angry face and made faster fixations to those faces than to neutral faces. The neural basis for this automatic process lies primarily within the amygdala, a region involved in automatic vigilance and threat detection (Davis & Whalen, 2001). This is supported by neuroimaging studies demonstrating hyperresponsivity of the amygdala to threat in anxious adults and youth (Etkin & Wager, 2007; Swartz & Monk, 2014). Exaggerated amygdala responses to threat have been observed across multiple tasks and are particularly strong in response to rapid or subliminal presentation times, highlighting the "automatic" nature of this response (Eldar, Yankelevitch, Lamy, & Bar-Haim, 2010; Monk et al., 2008). This suggests that for anxious children and adolescents, the amygdala's threat detection mechanism is hypervigilant. As a result, they detect actual threat more readily as well as have a lower threshold to determine whether a stimulus indicates threat (Vasey & MacLeod, 2001; Waters, Craske, Bergman, & Treanor, 2008). Given the temporal limitations of fMRI, direct examination of this early attention capture has relied on the superior temporal resolution of scalp-recorded event-related potentials derived from electroencephalography (EEG). These show evidence of this early attention capture in posterior visual regions within the first 200 ms of stimulus onset (Bar-Haim, Lamy, & Glickman, 2005; Carretié, Martin-Loeches, Hinojosa, & Mercado, 2001; Carretié, Mercado, Tapia, & Hinojosa, 2001; Dennis & Chen, 2007; Eldar et al., 2010; Helfinstein, White, Bar-Haim, & Fox, 2008; Mueller et al., 2009). Because this initial attention capture occurs at speeds that preclude behavioral responses, it is not what is being measured by dot probe response times. Rather, the behavioral differences in biases toward and away from threat likely occur at the next stage of strategic processing that relies on cortical functions (Cisler & Koster, 2010).

Poor Disengagement

Once threat is detected, there are three possible outcomes: poor disengagement from the threat (resulting in attention bias toward threat as measured by behavioral assays), attentional avoidance (resulting in attention bias away from threat), or no consistent pattern of responding at all (no discernible bias). The first, poor disengagement, suggests a disruption in adaptive attentional redirection. In adults, high trait anxious individuals have greater difficulty disengaging from threatening stimuli than those with low trait anxiety (Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006; Leleu, Douilliez, & Rusinek, 2014; Sheppes, Luria, Fukuda, & Gross, 2013). Although similar studies have not been conducted in school-age children or adolescents, it has been shown that 12-month-old infants who have difficulty disengaging from threat (fearful faces) exhibit greater negative affect (Nakagawa & Sukigara, 2012). These anxiety-related deficits in disengagement likely reflect impairments in cognitive control, as evidenced by a behavioral study of children and adolescents in which effortful control moderated the relationship between negative affect and TB (Lonigan & Vasey, 2009). Specifically, in children with high negative affect, only those with low effortful control exhibited an attentional bias to threat, suggesting they were not able to effectively shift their attention. Similarly, in a study of more than 150 children, attentional biases toward angry faces were associated with anxiety only in those with low levels of self-reported attentional control (Susa, Pitică, Benga, & Miclea, 2012). A second study published from these data found that children with high fear and low attentional control showed an attentional bias toward threat that was not observed in those with low fear (Susa, Benga, Pitică, & Miclea, 2014). These studies are limited by the use of self-report measures of cognitive control, suggesting the need for future investigations using behavioral measures of nonemotional cognitive control.

These deficits in disengagement from threat are thought to result from reduced recruitment of dorsolateral prefrontal cortex (DLPFC), a region involved in attentional control (Peers, Simons, & Lawrence, 2013). This has been demonstrated in behavioral studies that manipulate the level of DLPFC recruitment during threat appraisal. For example, in a study of working memory load, a sample of socially anxious undergraduates exhibited avoidance of disgust faces when working memory load was low. However, when it was high, they had difficulty disengaging (Judah, Grant, Lechner, & Mills, 2013). Studies using distractor tasks have shown reduced recruitment of DLPFC associated with heightened anxiety in healthy adults, suggesting an inability to recruit this region to provide sufficient top-down attentional modulation (Bishop, 2009; Bishop, Duncan, Brett, & Lawrence, 2004). Similarly, in a study of young adults, greater frontal EEG activity during a negative mood induction was associated with less attentional interference by negative emotional distractors (Dennis & Solomon, 2010). Alternatively, Perez-Edgar et al. (2013) found that, when exposed to a stressful speech task, young adults who demonstrated greater frontal alpha asymmetry exhibited an attention bias toward threat during a dot probe task. This latter finding suggests a possible laterality in the role of the DLPFC in vigilance and attentional control. In summary, evidence supports a role of the DLPFC in attentional control and thus, deficits in this region are proposed to underlie difficulties in disengagement from threat resulting in observed TB in anxious youth.

Attentional Avoidance

As evidenced earlier, studies suggest that if prefrontal regulatory regions are not working effectively, then attention cannot be disengaged from threat, resulting in an attention bias toward threat. Thus, avoidance or shifting of attention away from threat may be the adaptive response. However, in the context of anxiety disorders, avoidance is frequently considered maladaptive because it does not allow for extinction of the fear response or disconfirmation of feared outcomes. Behaviorally, it has been shown that compared to controls, anxious children endorse more avoidant strategies in response to threatening scenarios (Barrett, Rapee, Dadds, & Ryan, 1996; Chorpita, Albano, & Barlow, 1996). However, few studies have directly examined neural mechanisms associated with avoidance. Recent adult EEG studies implicate the parietal cortex. For example, Grimshaw, Foster, and Corballis (2014) found that when completing a dot probe task with long stimulus durations (1,050 ms) among women with rightward frontal asymmetry, those with low right parietal activity showed vigilance for threat whereas those with high right parietal activity showed avoidance. This is consistent with other data showing an association between right parietal asymmetry and avoidance of emotion faces (Perez-Edgar et al., 2013). Models of avoidance based on nonhuman studies implicate regions such as the striatum in the negative reinforcement processes involved in avoiding aversive events. This was recently examined in healthy children using an instrumental avoidance paradigm (Schlund et al., 2010). Relative to a control cue, greater activation was found in the caudate and putamen, as well as the insula, amygdala, and thalamus, to the avoidance cue. The authors suggest that the amygdala activation signals the salience of the cue whereas the striatum represents the instrumental response of avoidance. Of note, amygdala and insula responses were sustained even after initial avoidance learning, which suggests that the avoidance cue continued to be salient even when the threat could be avoided. This is consistent with the persistence of fear reactions in anxious children and adolescents even when they engage in avoidance behaviors. Evidence from reward paradigm studies suggest hyperresponsivity of the striatum in socially anxious youth and those at temperamental risk for anxiety (Guyer et al., 2012; Guyer et al., 2006). Further investigation of striatal responses to avoidance of negative outcomes, as well as parietal function, is needed.

Absence of Attention Bias

The absence of an attentional bias is most often seen in nonanxious youth and thus, may represent the most adaptive response to the dot probe task. This suggests that the automatic vigilance toward threat may be absent in these children, or the initial preattentive bias is there, but the subsequent responses shift between vigilance and avoidance resulting in no clear pattern of responding. The latter would require greater attentional control and/or cognitive flexibility, which is typically deficient in anxious individuals (Lee & Orsillo, 2014). For example, self-reported ability to focus attention has been shown to be associated with lower anxiety in adults (Reinholdt-Dunne, Mogg, & Bradley, 2013). Similar results have been found in pediatric samples. A study by Susa et al. (2012) showed that children endorsing higher attentional control reported less anxiety on questionnaire measures. Together, these findings suggest that anxious youth are typically deficient in cognitive control. However, for those who do not exhibit attentional TB, cognitive control may be intact, allowing them to respond more flexibly when their attention is initially captured by threatening stimuli. Alternatively, these children may not evidence early facilitated attention to threat and thus, may not require significant attentional control when they perform the task. Either way, this may represent an additional subset of anxious youth for whom traditional etiological models of attentional vigilance and avoidance do not apply.

Testing the Neurocognitive Model

To test this neurocognitive model, TB and neural activity must be assessed simultaneously. To date, few studies have done this in anxious youth. In one study, during a dot probe task with 500 ms stimulus durations, adolescents with GAD exhibited greater activation in right ventrolateral prefrontal cortex (VLPFC) as compared to healthy comparisons, with no differences in amygdala responsivity (Monk et al., 2006). Furthermore, VLPFC activity was negatively correlated with anxiety severity, suggesting that this region may be playing a compensatory role, modulating abnormal amygdala activity. Of note, the adolescents with GAD exhibited an overall bias away from threat, and the VLPFC activation remained significant even after controlling for this. Thus, involvement of the VLPFC may reflect an emotion regulation process that is not related to attentional strategies. Similarly, a recent dot probe study used magnetoencephalography to show anxiety-related differences in VLPFC activation during responses to the probes and not to the threatening stimuli (Britton et al., 2012). In the healthy controls, this activation was negatively correlated with anxiety scores, similar to Monk et al. (2006). However, no significant attention biases were observed for either group and thus, again, it is likely that the VLPFC activation was related to other emotion regulation strategies. This is consistent with recent reviews suggesting a role of the VLPFC in salience detection and signaling the need to regulate subcortical responses (Kohn et al., 2014).

Development of Key Brain Networks

One of the challenges of understanding attentional TB and their underlying neural mechanisms in children and adolescents is the significant brain development that is taking place in fronto-limbic circuitry (Somerville, Jones, & Casey, 2010; Spear, 2000). Specifically, processes of synaptic pruning and myelination in prefrontal cortex during adolescence are synchronous with the development of several executive functioning processes related to attention such as processing speed and response suppression (Luna, 2009). In contrast, the amygdala does not undergo such radical change in adolescence (Giedd et al., 1996), although recent evidence suggests that it may exhibit a transient increase in volume during this period. Thus, these maturational changes lead to an "immature supervisory role" (Ernst, Pine, & Hardin, 2006, p. 5) for the prefrontal cortex over subcortical regions such as the amygdala, which may result in enhanced amygdala reactivity to threatening stimuli in adolescents compared to adults and children (Hare et al., 2008). Puberty-related changes in these circuits have also been observed. Forbes, Phillips, Silk, Ryan, and Dahl (2011) showed that, compared to an early puberty group of adolescents, a mid/late-puberty group showed less amygdala activity to neutral faces and less ventrolateral prefrontal cortex reactivity to fearful faces. Although there is clear evidence of neurobiological changes occurring between childhood and adolescence in regions that would be assumed to impact attentional biases, there is no support for developmental differences in behavioral measures of attentional TB. Nearly all studies of attention bias using the dot probe (and other measures) include participants across a wide age range, varying from 5–13 years (Waters et al., 2014) to 8–18 years (Britton et al., 2012). Few of these studies examine the impact of age, and those that do have not found any significant results. In light of what is known about neural development and the significant variability in attentional TB during childhood and adolescence, this is clearly an area that warrants further investigation.

In summary, neurocognitive models of the anxiety-related TB suggest that vigilance for threat at the neural level, as evidenced by amygdala hyperresponsivity, coexists with two putative behavioral responses, impaired disengagement and attentional avoidance, that likely emerge from disruption of prefrontal and/or parietal control mechanisms. However, other studies have found no discernible bias suggesting no consistent responding, which may reflect either a lack of initial amygdala hyperresponsivity and attention capture, or more adaptive attentional processes, in this subset of anxious youth. Although age has not been shown to impact attentional TB, there are clear neurodevelopmental changes occurring that are likely to impact these processes and contribute to the onset of anxiety disorders during this time. There is a significant need for more careful, standardized multimethod examination of attention to threat at all levels, from initial orienting to later attentional engagement, across ages and anxiety levels, to tease apart the exact mechanisms involved and how they contribute to the development and maintenance of pediatric anxiety disorders.

Clinical Implications

What are the implications of such a model for clinical treatments of pediatric anxiety disorders? Recent work has started to examine how TB can be altered to reduce anxiety and also to determine whether initial attentional biases predict outcomes of more traditional treatments such as CBT. ABMT is a cognitive training intervention that results in significant reductions in anxiety in adults (Hakamata et al., 2010) with growing evidence in children (Bechor et al., 2014; Eldar et al., 2012; Rozenman, Weersing, & Amir, 2011). It is computer-based, typically using the dot probe to systematically train attention away from threat by repeatedly pairing the probe with the non-threatening stimulus location (MacLeod, 1995). Given that some anxious children show attentional avoidance of threat, or no bias at all, the broad clinical applicability of ABMT is uncertain. Because of this unresolved issue, the largest trial of ABMT for pediatric anxiety only included children with a bias toward threat (56% of children screened; Eldar et al., 2012). Significant decreases in anxiety and TB scores were found; however, the TB reduction did not statistically mediate improvement in anxiety, and thus, the mechanisms by which anxiety was reduced are unclear.

Because decreased TB was not found to mediate symptom improvement, the question becomes whether ABMT could also be effective for children without a pretreatment TB. Several ABMT studies have included children regardless of baseline TB with promising results. For example, in an open pilot of 16 children (mean age = 14 years, range = 10–17 years), twelve 15-min sessions of ABMT resulted in reductions in anxiety but no significant changes in TB scores (Rozenman et al., 2011). The authors attribute this lack of significance to the large variability in bias scores at baseline, although ranges are not reported. In a larger, placebo-controlled randomized clinical trial of ABMT in 34 chronically trait anxious 10-year-olds, Bar-Haim, Morag, and Glickman et al. (2011) showed greater disengagement from threat in the ABMT group than in the comparisons, although both groups exhibited decreases in anxiety. In the ABMT group, greater ability to disengage from threat was correlated with a lower anxiety response to a stressor task; this was not found in the control group. Additional studies have shown reductions in anxiety following training toward positive stimuli using a visual search task (Waters, Pittaway, Mogg, Bradley, & Pine, 2013) and when using ABMT to treat children who failed to respond to CBT (Bechor et al., 2014). Overall, although there is evidence of ABMT-related improvements in anxiety in children, these improvements appear unrelated to initial TB or to changes in TB over the course of treatment. This raises questions regarding the mechanism by which ABMT is working to reduce anxiety for which we do not have answers (Heeren, De Raedt, Koster, & Philippot, 2013). Improved understanding of the heterogeneity of attentional responses to threat in anxious children and adolescents and their neural basis should provide a stronger foundation on which further ABMT investigations can be based.

Greater understanding of attentional TB may be similarly useful for traditional CBT. For example, children who show initial attentional *avoidance* of fear-relevant stimuli may more readily benefit from exposure-based treatments that gradually increase engagement. This is supported by Legerstee et al. (2009) who showed that anxious children who were diagnosis-free after CBT, were more likely to show an initial attention bias away from highly threatening images. This effect was not found for less threatening images. Alternatively, cognitive-behavioral theories posit that fear structures must be fully engaged for exposure to be effective (Rauch & Foa, 2006) and that distracting oneself from feared stimuli can interfere with extinction (Kamphuis & Telch, 2000). Therefore, youth with an initial bias toward threat might demonstrate improved benefits of exposure-based treatments because of enhanced attentional engagement with anxiety-provoking situations or objects. In a sample of 35 children (ages 6–12 years) with social phobia or GAD, Waters, Mogg, and Bradley (2012) found a greater reduction in anxiety symptom severity in anxious children who had a baseline attention bias toward threat (angry faces) relative to those with an attention bias away from threat. Of note, these studies differ considerably in terms of sample characteristics (age, diagnoses), and intensity of threatening stimuli making it difficult to formulate definitive conclusions. However, this is clearly a promising area of future research because children's initial attentional style may be an important factor to consider when selecting anxiety interventions.

Summary

Attentional bias toward threat has long been considered a key cognitive vulnerability factor for pediatric anxiety disorders. As a result, there has been significant enthusiasm surrounding targeted interventions such as ABMT that train attention away from threat to ameliorate anxiety. However, careful examination of the pediatric literature reveals heterogeneity in attentional biases, suggesting that focusing research efforts on such treatments may be premature. According to neurocognitive models, biases in attention observed using tasks such as the dot probe involve multiple processes, starting with an initial vigilance toward threat mediated by amygdala hyperresponsivity. Once attention is captured, impaired disengagement, proposed to result from deficient DLPFC function, results in a bias toward threat, whereas an avoidant response, putatively mediated by parietal cortex and/or striatum, results in a bias away from threat. Anxious youth who do not demonstrate a discernible bias may represent a third group who either do not evidence early vigilance toward threat or who do not respond to threat with consistent attentional responses. Rigorous evaluation of these variations in TB at multiple levels of processing, including direct neural measures such as EEG and neuroimaging, is needed to test these models. Furthermore, given the limitations of the dot probe, there is a clear need for alternative attention-emotion tasks and the improved measurement of attention using direct assessments such as eye tracking. The time has come to take a "step back" and examine these unique patterns of attentional TB not as "noise" but as meaningful individual differences with the aim of identifying distinct phenotypes with important implications for predicting clinical course and treatment response.

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